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Environmental Energy Technologies Division Lawrence Berkeley National Laboratory

Toward future's clean power system: lessons from the past

Berkeley Tsinghua Energy Forum

LIN Jiang, and Andrew Satchwell

October 21, 2016

劳伦斯引入大团队科学研究
劳伦斯伯克利国家实验室：能源部第一个国家实验室

13 Nobel Prizes

Luis W. Alvarez

Melvin Calvin

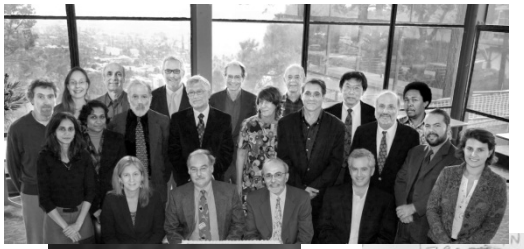
Owen Chamberlain

Steven Chu

Donald A. Glaser

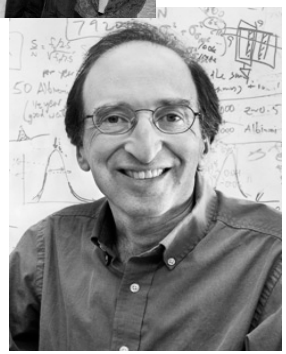
Ernest Orlando Lawrence

Yuan T. Lee



Intergovernmental Panel on Climate Change (IPCC)

Edwin M. McMillan



Saul Perlmutter

Glenn T. Seaborg

Emilio G. Segrè

George F. Smoot

History of Electricity Reform in US

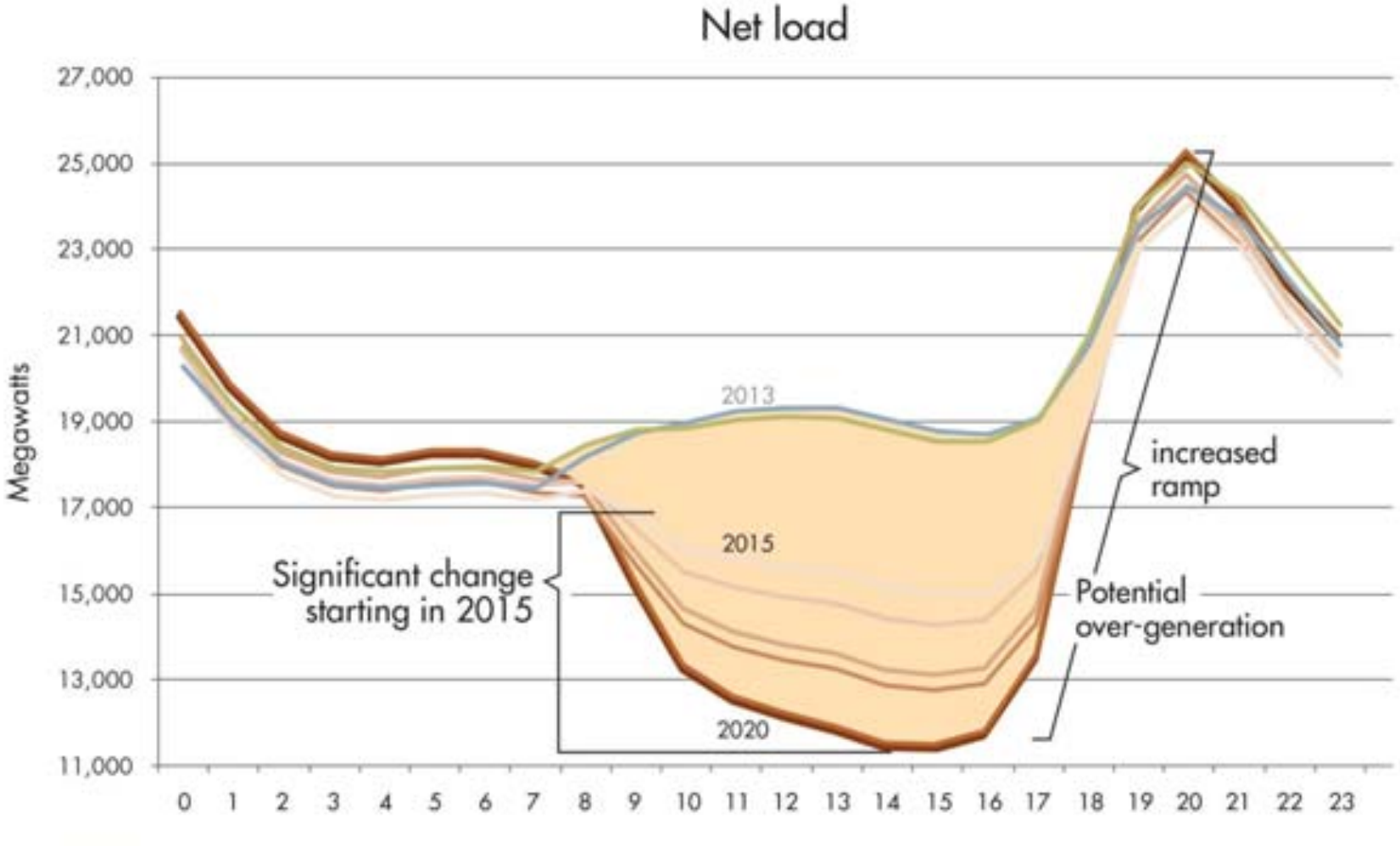
- History of Deregulation of Utility since 1990
- Emergence of RTO/ISO and wholesale market

California: *the clean power frontier*

- Most ambitious goal for renewable power
  - 33% of renewables by 2020
  - 50% of renewables by 2030 (excluding hydro)
- Half of solar installation in US
- Leaders in energy efficiency in US
  - Appliance standards
  - Building codes (updated every three years)
  - "Decoupling" and strong utility efficiency programs
- Robust carbon market covering power sector

The Future: can the duck fly?

- Duck Curve



History of Deregulation since 1990

- Pre-1990
  - Vertically integrated utilities
  - Cost of services regulation
- 1990 Restructuring/deregulation
  - Unbundling of generations from T&D
  - Direct access/Retail competition
  - Wholesale power markets
- Current thinking
  - ***Meeting environmental/climate targets***
  - Deregulation inactive
  - Emergence of ISO/RTO
  - Wholesale power market
  - Retail competition
  - ***Future utility model (NY REV)***

History of Power Sector Reform

- Goals:
  - Reliable supply of power at least cost
- Pre-1990
  - Vertically integrated utilities
  - Cost of services regulation
- Problems
  - Overly optimistic forecast of future demand growth
  - High cost of generation
- Solutions
  - Lead to some separation of functions, ie, independent demand forecast
  - Lead to deregulation of utilities

Optimistic, or system-bias?

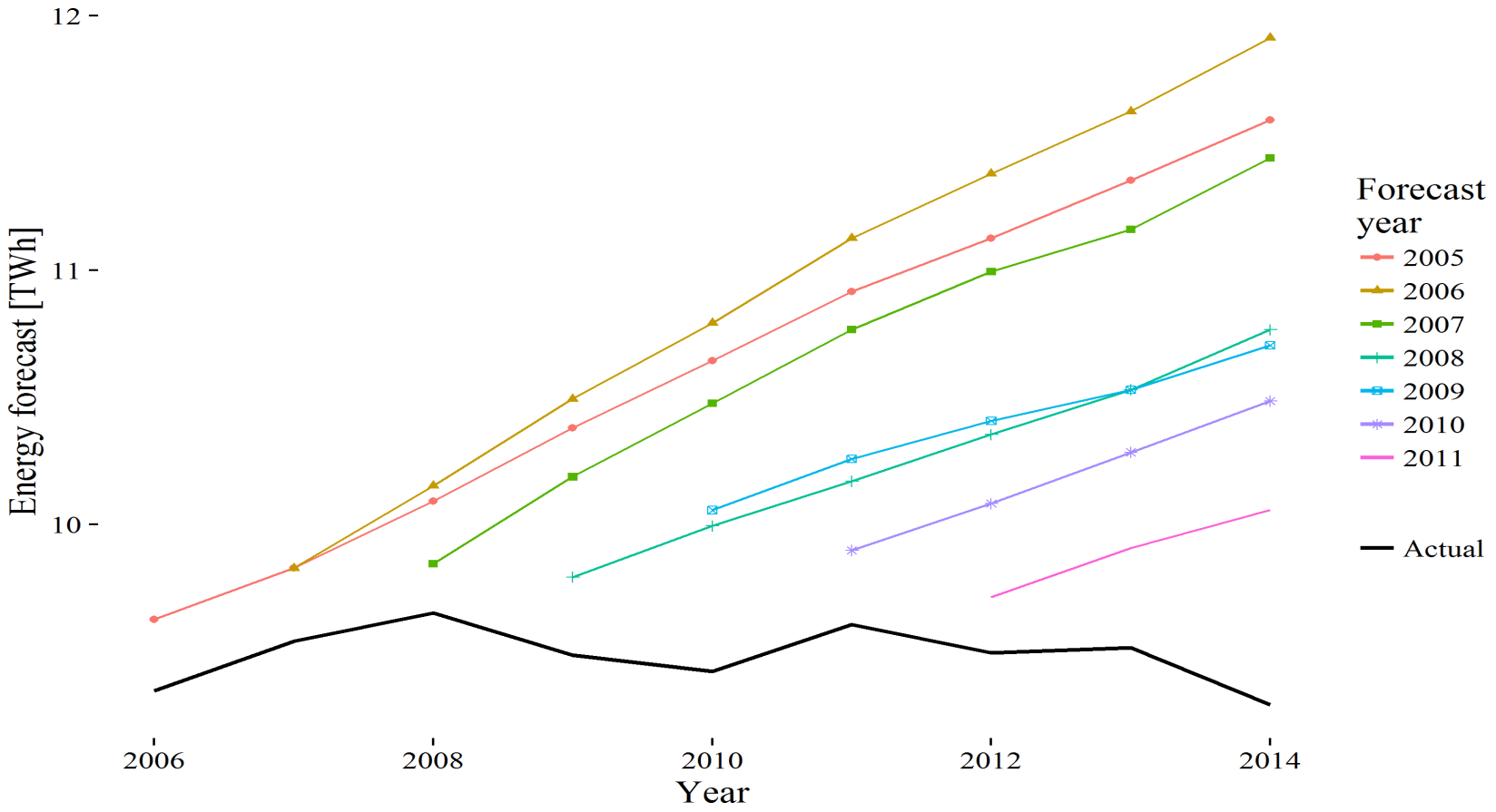
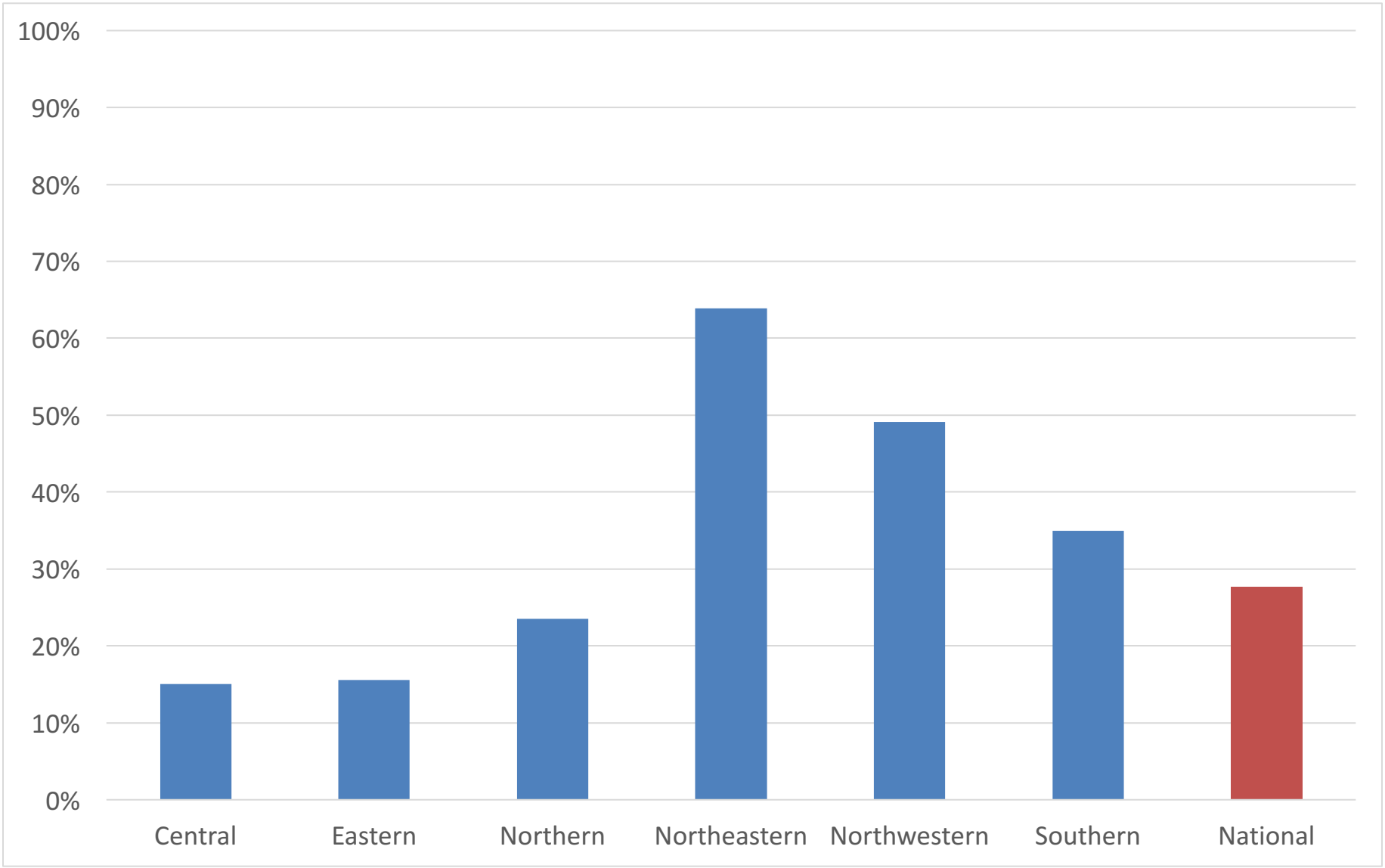
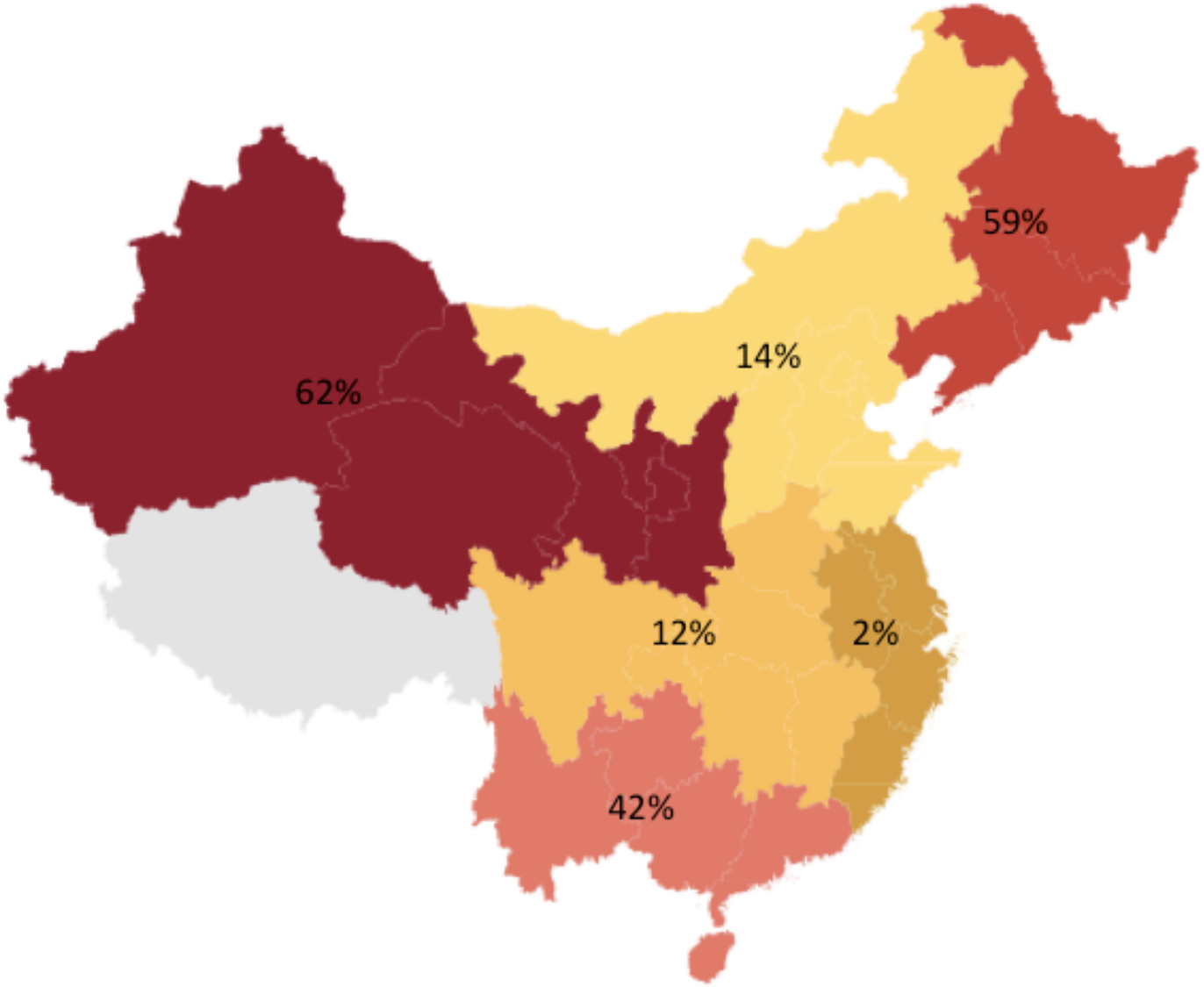


Figure ES-1 Load forecasts from seven subsequent IRPs and actual load for a Western U.S. utility.

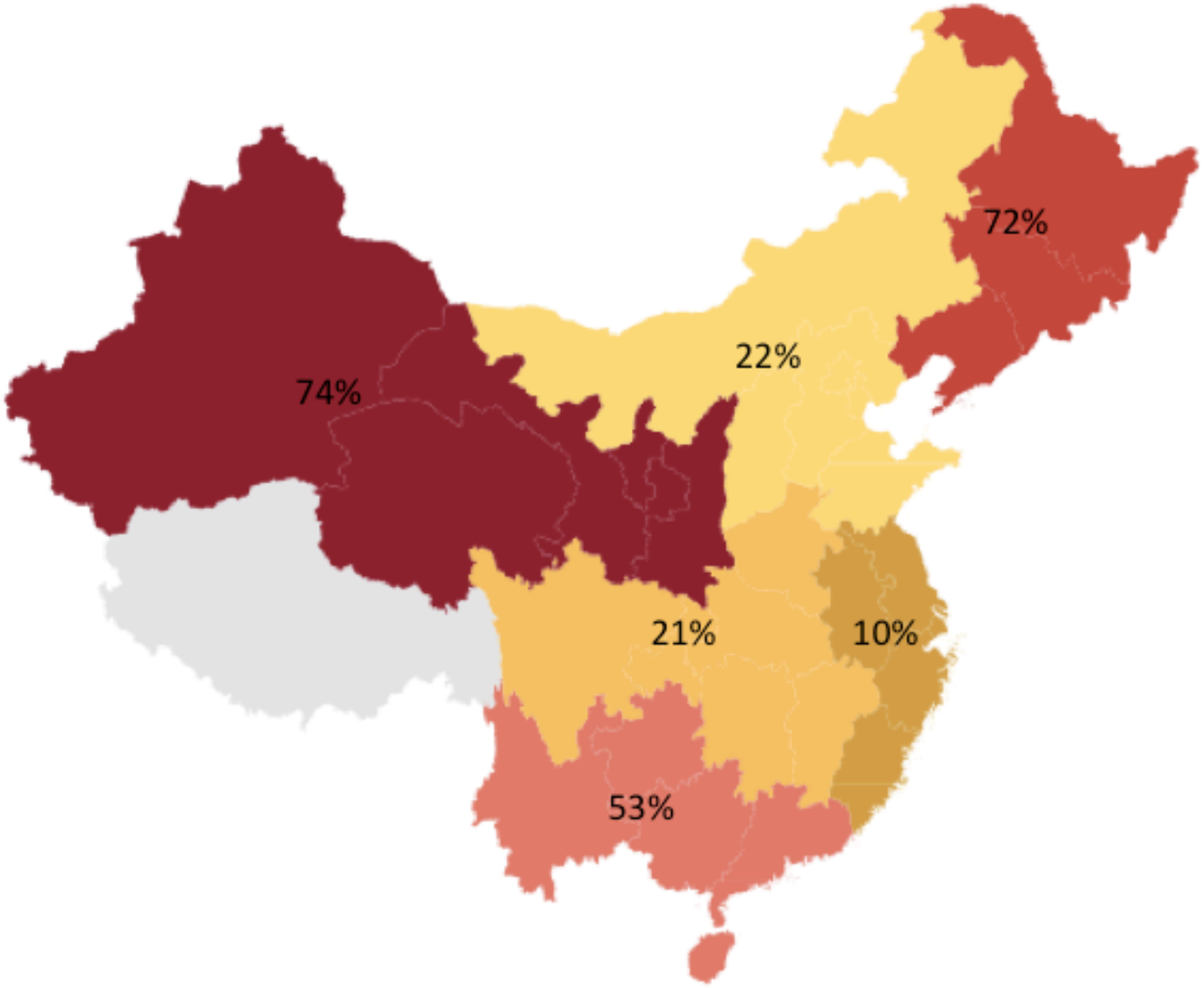
Planning reserve margins in China, 2014



Planning Reserve Margin in 2020 under the High Growth Scenario



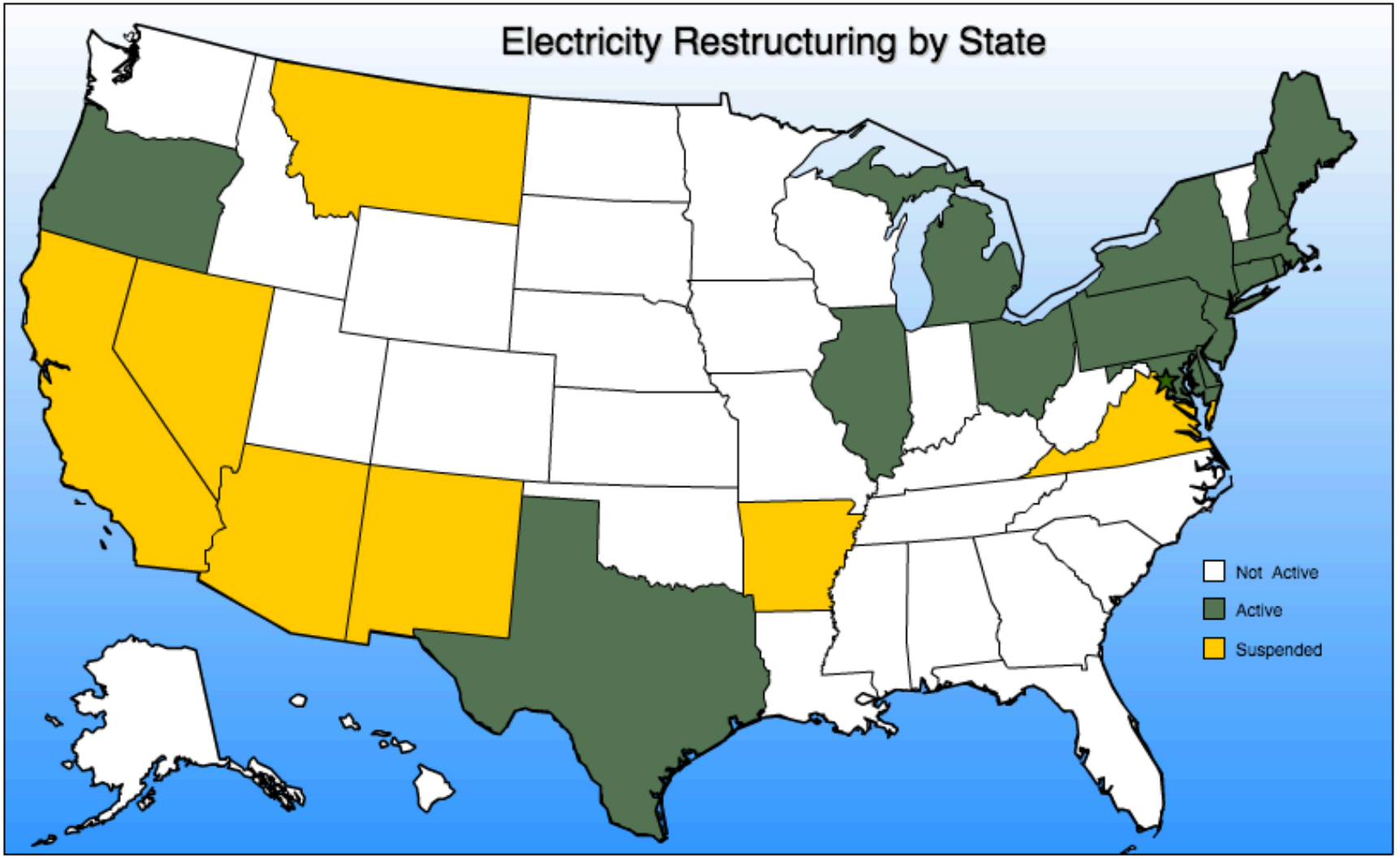
Planning Reserve Margin in 2020 under the Low Growth Scenario



History of Power Sector Reform: mid-1990s to 2010

- Goals
  - Increasing economic efficiency and reduce costs
- 1990s Restructuring/deregulation
  - Unbundling of generations/retails from T&D
  - wholesale market
  - Direct access/retail competition
- Problems: CA crisis in late 1990s
  - 2000-2001: poor market design and market manipulations led bankruptcy of two large IOUs
- Solutions:
  - Some states back to re-regulation
  - Many remain the unchanged

Deregulation has stalled in most states



Source: Energy Information Administration

Rate Impact Limited:

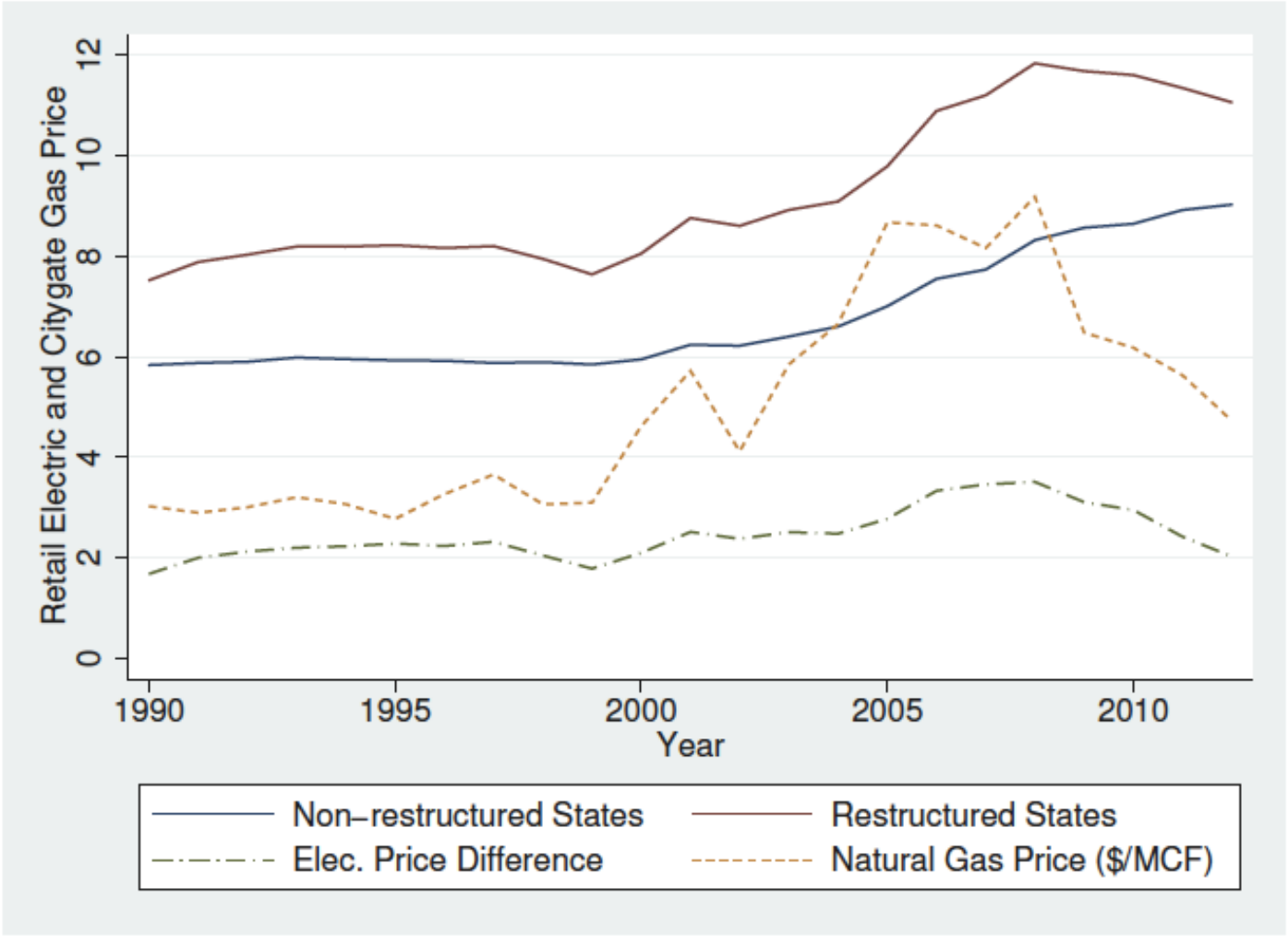


FIGURE 6. U.S. AVERAGE RETAIL RATES AND NATURAL GAS PRICES

Borenstein and Bushnell, 2015

Observation: Utility Deregulation in US

- Still heavily regulated industry
- Unbundling of generation and competition improved efficiency at power plants
- Open access to transmission grid is essential
- *Improved coordination of power grids (ISO/RTO)*
- Limited impact on ***average*** consumer costs
  - Economic vs social costs?
- Other benefits unclear:
  - how to value customer choice?
- Implementation poses significant challenge

Drivers of current reforms

- Environmental/Climate Change
  - Meeting GHG targets
  - RPS
  - Clean Power Plan
- Technological
  - Rapid cost reductions and expansion of for solar and wind
- Business model
  - Leasing
- Utility model
  - Customer defection
  - Declining revenue base

RTOs/ISOs and wholesale energy markets in the US

What is an RTO/ISO?

- **independent** organizations managing transmission access
- Responsible for the economic scheduling of generation that takes into account reliability and capacity constraints on transmission system
- Three key RTO/ISO roles:
  - Generation and load balancing for transmission reliability
  - Market operations
  - Planning
- Don't own power lines, substations, or other utility equipment
- Are a neutral party monitoring the transmission network and managing competitive energy markets

Where are the RTOs/ISOs?

- Seven in the U.S. and market rules and tariffs are regulated by Federal Energy Regulatory Commission (FERC)
- Some parts of the U.S. have no RTO/ISO and instead utilities offer open transmission access tariffs and rely on bilateral energy contracts

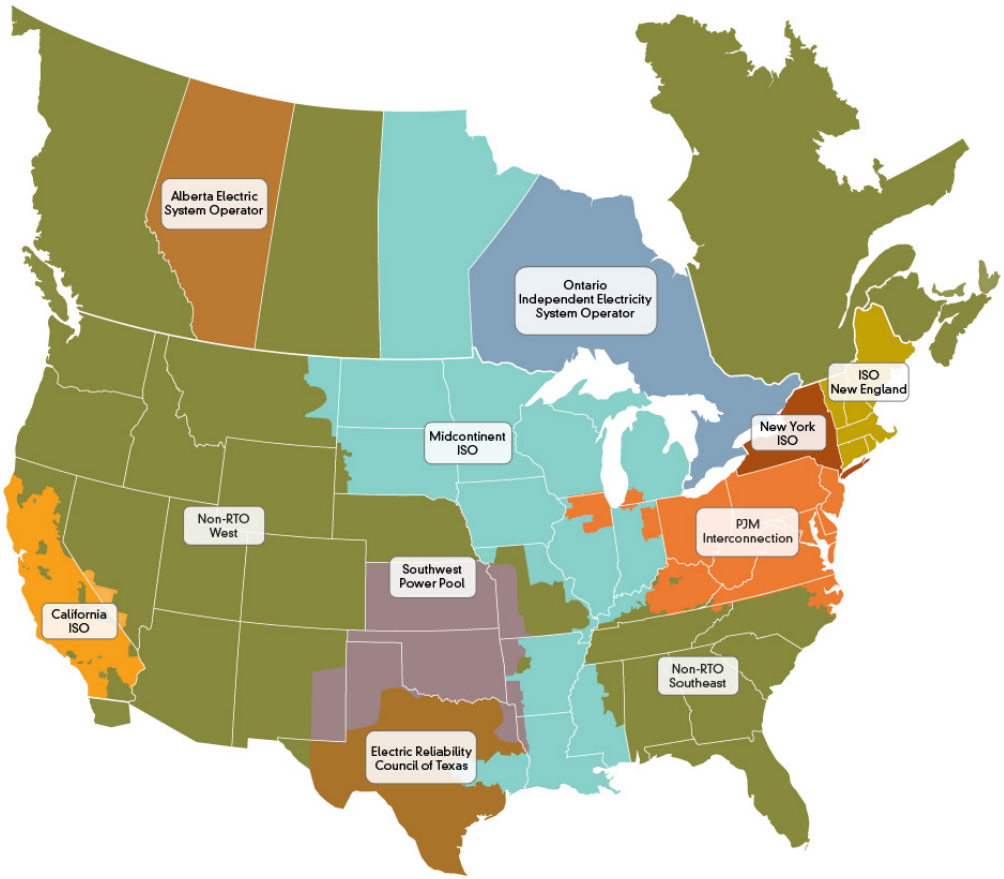


Figure: http://sustainableferc.org/iso-rto-operating-regions/

Wholesale Energy Markets

- Purpose is for the economic efficient use of transmission and generation
- Market products and rules vary among RTO/ISO

	CAISO	ERCOT	ISO-NE	MISO	NYISO	PJM	SPP
Day-Ahead/ Real-Time Energy Market	✓	✓	✓	✓	✓	✓	✓
Capacity Market			✓	✓	✓	✓	
Regulation Market	✓	✓	Real time only	✓	✓	Real time only	✓
Offer Energy Floor/Cap ($/MWh)	-150/1000	-250/7000	-150/1000	-500/1000	None/1000	None/1000	-500/1000

Lessons learned

- Utility industry is likely to remain carefully regulated
  - Wholesale market is complicated and takes time to form, needs to be carefully monitored and regulated
  - Need to balance economic, social, and climate goals
- Competitive generation has led most of the economic efficiency gains.
- Rate impact on average consumers has been limited.
- ISO/RTO have improved grid operation
- Independent demand forecast is foundational to good resource planning
- Meeting climate goals require new thinking

Research Questions

- What types of models are best suited for load forecast?
  - At what geographic/demographic resolution?
- What KPIs to evaluate retail competition/choice? Wholesale competition?
- Generation planning quota: is it time to phase it out?
- What mechanism to ensure environmental and climate goals?
- What infrastructure is needed to make both production and demand more “responsive”
  - Dynamic pricing?
  - Tools to allow operators and consumers to make smart choices

- Thank you
- J_lin@lbl.gov